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ABSTRACT

A pilot study was conducted to ascertain if creative abilities measures could be adapted to the upper elementary school level and maintain their factorial validity. The factorial validities of seven measures of productive thinking abilities at the upper elementary school level were tested across grade levels and different socio-economic communities. Factor structures for sub-samples defined by grade and community were compared with factor matrix obtained for the total group. Results showed that the factor structures of the total sample and sub-groups were similar. Three measures of divergent production abilities maintained validity and were independent of I.Q. Further development and validation of such tests in this manner may produce intellectual measures useful in studies of pupils from widely different socio-economic backgrounds. (Author)

STABILITY OF PRODUCTIVE THINKING FACTORS ACROSS DIFFERENT COMMUNITIES AND GRADE LEVELS

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Many of the achievement measures usually used in educational evaluation do not seem to provide enough data about how educational programs effect pupils' development on the more complex intellectual skills such as productive thinking and evaluation. Most measures which have been developed and standarized for higher cognitive skills are useable only with teenagers or adults. For the evaluator of elementary education programs, there is a dearth of instruments available to him. Prior to the inception of this study a particular need was felt by the evaluators of an individualized elementary school program to show whether or not the program effects abilities related to verbal creativity. Using the structure of intellect model as a guide, seven tests were selected which had been shown in the past to be relatively factorially pure measures for abilities hypothesized to contribute to creativity in the semantic area. A pilot study was conducted to see if these tests could be adapted to the upper elementary school level, grades four through six, and maintain their factorial validity. That pilot study is the subject of this report.

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Structure of intellect factors selected for the study include the following:

CMI - Cognition of Semantic Implications (conceptual foresight). This factor represents the ability to foresee the possible consequences or implications of a problem and/or its solutions.

DMU - Divergent Production of Semantic Units (ideational fluency). Tests for this factor demonstrate ability to generate a large number of ideas about a certain problem.

DMR - Divergent Production of Semantic Relations (associational fluency). This may be an ability to make meaningful connections between ideas by association thus leading to possible solutions to a problem.

DMT - Divergent Production of Semantic Transformations (originality). Tests for this factor seem to measure quality of responses rather than quantity as is implied by DMU. The responses sought are remote or clever and involve making unusual changes in ideas.

EMI - Evaluation of Semantic Implications (sensitivity to problems). This represents the essential first step in creative problem solving: that is, the ability to see the need for a solution.

Tests for these factors were adapted from those used in two previous studies by Merrifield, et. al. (1964) and Schmadel, et. al. (1965) with sixth and seventh grade children. These tests are as follows:

1. "Ways To Do It" measures CMI, ability to see all the elements involved in a problem and to see solutions that will meet the problem requirements. Each item in this test presents a job to be done and the pupil must tell as many ways as he can to do it. Sample Question: You have a deck of playing cards with the picture of a dog on the back. How many ways can you sort the cards, so that all the cards you put in the same group have something alike?

2. "Similar Meanings" measures DMR, ability to produce related ideas. It asks the child to think of many different words which mean almost the same thing as a given word. Sample Question: What words mean almost the same as GOOD?

3 & 4. "What Would Happen" gives the child a pretend change in the world and asks him to imagine other changes that it would cause. The test is scored in two ways to measure two different abilities. More obvious changes are counted to show ability to produce many simple ideas, DMU. Remote or way out changes are counted to show how well the child can think up unique or clever changes in ideas, DMT. Sample Question: What would happen if no one needed or wanted sleep?

5. "Seeing Problems," as its title indicates, measures EMI, ability to see problems connected with an object. The name of an object is given and the child is asked to write down problems in using or taking care of it. Sample Question: What are some problems with a candle?

6 & 7. "Names for Stories" asks the child to make up titles for a short story. This test is also scored in two ways. Clever titles indicate DMT, ability to think of unique changes in ideas. Not-so-clever titles are counted to indicate DMU, ability to think up many simple ideas. Sample Question: There was a man who could not hear his wife talking. She got him a hearing aid. He kept it turned on for a while, but then decided she talked too much. So he wore his hearing aid, but kept it turned off. Write titles for the story.

For administration, the tests were grouped into two booklets to be used in two separate sessions. Each session contained about thirty minutes of testing with additional time allowed between tests for giving directions. There were three separately timed parts in each test, and a full page was devoted to each part, giving pupils adequate space for writing answers. Together, these tests were titled Measures of Children's Abilities: Productive Thinking--Series M. They are copyrighted by Sheridan Psychological Services, Beverly Hills, California. At the end of the second booklet a short test of writing speed, in which the children were given one minute to write the alphabet as many times as they could, was included.

The tests were administered by specially trained testers to children in grades three through six on two consecutive days in early March, 1969. Approximately 1,300 pupils were tested in six schools, three individualized schools and their respective controls. The three pairs of schools represented three school districts in the North Eastern United States reflecting various degrees of urbanization. District one was a relatively affluent, white, semi-rural system. The schools from the second district represented the primarily white outskirts of a city with a large ethnic group population. District three schools were from the inner city and had mostly black students.

Scoring of these open-ended tests was done by ten trained clerks with high school educations. Inter-rater reliabilities for the twenty-one part scores of the Productive Thinking battery ranged from .63 to .99 with eighteen of the twenty-one correlations above .80.

Twenty-seven variables were included in the analysis of the data. These were treatment (individualized instruction versus the control), school district, grade, sex, verbal I.Q., writing speed, and the twenty-one part scores on the Productive Thinking battery. Since I.Q. scores were not available for the third graders, only children in grades 4, 5, and 6 with complete data records, a total of 893 cases, were used in the analysis. The first step in the analysis was to obtain frequency distributions and descriptive statistics on each variable. Skewed distributions were then adjusted to make them symmetrical. Next, intercorrelations of the twenty-seven variables were obtained, and the correlations were corrected for course grouping. A factor analysis of the corrected correlation matrix was done using the Biomedical Computer Program, BMD-03M. In this analysis, the maximum absolute row values

were used as communality estimates. Because it was hypothesized that the analysis would yield five factors of productive thinking (see page 2 for description of hypothesized factors), it was judged advisable to consider six principal components to allow for the socio-economic, verbal I.Q., and grade influences. The BMD-03M program requires the specification of a minimum eigenvalue for the factors to be rotated; an eigenvalue of 0.5000 was chosen, and six principal components having eigenvalues greater than that number obtained. These six were then rotated to the varimax criterion. After factor analysis of the total group, the study population was split by grade and school district and nine separate factor analyses were done for the nine sub-samples thus created. Factor structures (varimax criterion) of the nine sub-samples were compared with that of the total sample.

The Total Sample Factor Matrix

When the intercorrelations of the twenty-seven variables for the total sample were factored, six principal factors appeared to exhaust most of the common variance; the sum of the six eigenvalues for these factors was equal to 94% of the sum of the communality estimates in the correlation matrix. These six factors were rotated to the varimax criterion. The rotated factor matrix is presented in Table I.

[Insert Table I about here]

Factor A was interpreted to represent the effect of maturation or increasing level of grade in school on pupils' scores. The factor contained significant loadings for the following variables:

Grade	.62
Writing Speed	.51
Ways To Do It, Part 1	.48
What Would Happen (remote) Part 2	.40
What Would Happen (remote) Part 1	.38
Ways To Do It, Part 3	.37
Seeing Problems, Part 3	.30
Seeing Problems, Part 2	.30
Sex	.30
Ways To Do It, Part 2	.29

Of the ability variables loading on this factor, five of them were from tests hypothesized for this study to measure abilities to deal with implications. Ways To Do It was hypothesized as a test for cognition of semantic implications, CMI, and Seeing Problems was thought to be a test for EMI, evaluation of semantic implications. What Would Happen seems logically to require examinees to produce implications; therefore, it is not surprising that two parts of What Would Happen (remote) exhibited common variance with the Ways To Do It and Seeing Problems tests. Perhaps Factor A represents an ability to produce implications which is related to maturation in this age group; this would be consistent with positive loadings of grade level and proficiency at writing speed. Viewed this way, Factor A might also have been interpreted to represent Divergent Production of Semantic Implications, DMI.

Factor B seemed to represent the ability Divergent Production of Semantic Units, DMU, often referred to as ideational fluency. It included significant loadings for the following variables:

Names For Stories (low)	Part 2	.80
Names For Stories (low)	Part 3	.78
Names For Stories (low)	Part 1	.74
Seeing Problems	Part 1	.38
Seeing Problems	Part 3	.35
Seeing Problems	Part 2	.32
Sex		.27
What Would Happen (obvious)	Part 2	.26

Names for Stories (low) was hypothesized to measure this factor at the outset of the study. The fact that parts of three different tests load on this factor is encouraging in that it suggests that the factor does not represent a single test but a mental ability that goes beyond a single measuring instrument. However, the case for test specific variance could be made.

For factor C, familiar tests from previous studies (Merrifield, et. al., 1964; and Schmadel, et. al. 1965) suggested its definition. It was interpreted as Divergent Production of Semantic Transformations, DMT, also referred to as originality. Variables loading significantly on factor C were:

Names For Stories (high)	Part 3	.72
Names For Stories (high)	Part 2	.70
Names For Stories (high)	Part 1	.60
What Would Happen (remote)	Part 1	.42
Seeing Problems	Part 1	.36
Seeing Problems	Part 2	.33
What Would Happen (remote)	Part 2	.29

Grade		.28
What Would Happen (obvious)	Part 2	.28
Ways To Do It	Part 2	.27

Names for Stories (high) and What Would Happen (remote) were the hypothesized tests for this factor. The evidence of the contribution of Divergent Production ability or originality to the other tests loading on this factor is logically acceptable. As in factor B, there is the possibility that specific and common variance are confounded in this result.

Factor D contains the following significant loadings:

School District		-.71
Lorge-Thorndike Verbal I.Q.		.65
Ways To Do It	Part 2	.52
Seeing Problems	Part 3	.49
Seeing Problems	Part 2	.49
Seeing Problems	Part 1	.45
What Would Happen (remote)	Part 1	.45
What Would Happen (obvious)	Part 2	.36
What Would Happen (remote)	Part 2	.34
What Would Happen (obvious)	Part 3	.30
Similar Meanings	Part 3	.29
Names For Stories (high)	Part 1	.29

This factor was defined primarily by Lorge-Thorndike Verbal I.Q. and school district with other significant loadings for parts from six of the seven tests in the Productive Thinking battery. One of them, Seeing Problems, hypothesized as a measure of EMI, had its highest loadings for all three parts on this

factor, which is not inconsistent with the strong dependence of the usual Verbal-I.Q. measures on processes of cognition and evaluation. The other factors (A, B, and C) on Which Seeing Problems had significant loadings indicate its task requirement of productive thinking processes showing it to be a rather complex test.

Factor D seems to represent some sort of generalized language or reading ability effecting performance on these semantic tests--an ability possessed in greater measure by pupils in the higher socio-economic school district (a lower numerical code denotes higher SES, thus the negative loading for school district). The pervasiveness of language skill or reading ability in the performances elicited by this battery of tests was evident in factor D. In the analysis, the use of data from a sample pooled over three grade levels and different socio-economic strata enhanced the opportunity for systematic covariance with language or reading skills to emerge. It is logically understandable that such language knowledge as measured by the Lorge-Thorndike Tests would facilitate performance on these semantic tests. However, it is apparent that systematic variation in this kind of language facility did not account for the systematic variability in performance evidenced by the remaining factors which resulted from this analysis. Other factors were independent of community and the kind of culturally biased language measure provided by the verbal I.Q. test.

The productive thinking variables which did relate to factor D should be noted. Out of ten loadings, eight were for parts of Ways To Do It, Seeing Problems, and What Would Happen (obvious and remote). These tests, as discussed

in connection with factor A, may measure some sort of ability to work with implications. Factor A seems to suggest that facility with implications is developing in intermediate grade children, and factor D seems to suggest that proficiency with language enhances that development. A plot of A versus D shows that if one disregards variables 2 and 3 (school district and grade), which are independent by the design of the study, the two bounding hyperplanes have normals on one of which the variables of Sex, Writing Speed, and Ways To Do It, Part 1 have significant projections, while I.Q., Ways To Do It, Part 2, and all 3 parts of Seeing Problems dominate the other. The latter is a language-implications composite. The two oblique hyperplanes are separated by approximately 40°, and their normals by 140°. This type of result is not found in the nine subsamples, in which variables 2 and 3 have no variability.

Factor E represented another ability independent of language and community. It is defined entirely by the three parts of the Similar Meanings test:

Similar Meanings	Part 2	.62
Similar Meanings	Part 1	.57
Similar Meanings	Part 3	.56

It was considered to represent DMR, Divergent Production of Semantic Relations, as hypothesized. It is possible that some test-specific variance is being confounded with common factor variances here.

The only test variables loading on Factor F are the obvious and remote scores for What Would Happen, Part 3. (There was also a barely significant positive loading for sex.) The loadings were as follows:

What Would Happen (remote)	Part 3	.51

What Would Happen (obvious) Part 3	-.46
Sex	.27

This factor is probably an artifact resulting from a situation where most examinees made nearly the same low number of responses to the question. When this happens, the mutually exclusive scoring procedure may induce a negative correlation. The negative correlation embedded in a generally low or positive matrix results in its "own factor." This seems to be the case with Factor F.

To summarize the factor structure for the total sample, six principal factors were rotated and interpreted. Three (factors B, C, and E) appeared to be hypothesized structure of intellect factors in the area of Divergent Production. They were DMR (Divergent Production of Semantic Relations), DMU (Divergent Production of Semantic Units), and DMT (Divergent Production of Semantic Transformations). These factors were independent of verbal I.Q. and school district or grade. A fourth factor (factor D) seemed to represent a generalized language facility defined by the verbal I.Q. measure and strongly related to community. The fifth factor (factor A) was interpreted as primarily reflecting the effect of grade in school or maturation. Both the I.Q. factor (factor D) and maturation factor (factor A) contained loadings for measures of ability hypothesized to deal with semantic implications (CMI & EMI) which did not appear as separate factors. The sixth factor (factor F) appears to be merely an artifact of the scoring procedure used and was defined by the two scores from only one test part.

The Sub-Sample Factor Matrices

Because of the large amounts of variance in factors A and D accounted for by the variables of grade and school district respectively, it was decided to stratify the sample on these two variables to see if their effects could be limited, thus allowing other intellectual factors to show up more clearly in the factor structure. Nine sub-samples--fourth, fifth and sixth grade groups in each of three school districts--were created. Correlation matrices without the variables of grade and school district were generated and factored by the same procedure described for the total sample. Perusal of the nine resultant factor structures revealed many similarities among them and with the total sample factor matrix.

I.Q. loaded on factors with the experimental tests in five of the nine sub-samples. The tests effected by I.Q. were Seeing Problems, Ways To Do It, and What Would Happen. These instances occurred in all three fifth grades and in one fourth grade and one sixth grade group. Analyses of the nine sub-samples showed that sex was related to writing speed in two groups, and to isolated parts from the What Would Happen and Ways To Do It tests in four other groups. Sex was related to the Names for Stories (low) test in two groups, and in one of those all three parts of the test had high loadings on this sex factor. As with I.Q., factor loadings for sex did not occur in any one particular grade or school district.

One of the strongest of the experimental tests seemed to be the Similar Meanings test for factor DMR, Divergent Production of Semantic Relations. This test occurred as a unique factor in all nine sub-samples. In one fourth

grade sample, it was related to writing speed, also. In four of the sub-samples one part from the Similar Meanings test had a noticably weaker factor loading than did the others.

Another strong factor test was Names for Stories (low) measuring DMU, Divergent Production of Semantic Units. This factor occurred in eight of the nine sub-samples with all parts having factor loadings significant at the .05 level. In one sixth grade group, sex was also strongly related to this factor with the girls doing better.

Names for Stories (high) occurred as a unique factor in five of the nine sub-samples. These were all on the fifth and sixth grade levels and represented all three of the school districts. The test measures DMT, Divergent Production of Semantic Transformations. In two fourth grade samples, parts 2 and 3 of the test loaded on this factor but part one did not, and in one fourth grade sample girls did better.

In one fourth grade sample, Seeing Problems emerged as a unique factor test. However, it is doubtful that it was measuring only the hypothesized factor, Evaluation of Semantic Implications (EMI), since the test parts loaded rather consistently with I.Q. in the other analyses, and in one sub-sample with DMU, Divergent Production of Semantic Units.

The nine sub-analyses do not seem to change greatly the picture obtained from the factor analysis of the entire group; factor structures for each grade and school district are similar. The confusion among the Ways To Do It,

What Would Happen, and Seeing Problems tests and I.Q. remains. All three of these aptitude tests seem to have something to do with the recognition and production of implications. If skill in the cognition of implications is underlying performance on these three tests, this could also help explain the relationship with I.Q., since intelligence tests generally contain measures of cognition; however, the hypothesized measure for CMI, Cognition of Semantic Implications had a poor showing in this study. The factors DMU, DMR, and DMT which did appear consisently and seemed to be unrelated to I.Q., school district, or age were all divergent production factors, which relate to the ability to think up many different ideas about one situation or idea. Names for Stories seems a useful measure for both DMU and DMT, relatively uninvolved with I.Q. Similar Meanings is a dependable measure for DMR. However, What Would Happen is disappointing, relative to its dependability in older examinees; similarly, Ways To Do It seems ineffective for this age level, and the question of whether CMI can be differentiated in such examinees remains unanswered. Seeing Problems, despite its involvement with verbal I.Q., provides an interesting and internally consistent measure of a relative distinct, though complex, ability.

Conclusion

Two overall results of this study are noteworthy. One is the separation among three divergent production factors, and an I.Q.--socio-economic factor, indicating that divergent production tests may show promise as ability measures which are more nearly fair in studies including both black and white children. The second noteworthy result is the confusion among tests apparently measuring ability to work with implications. These results suggest that seeing implications--perhaps a kind of sensitivity to problems--is a broad, rather fluid ability at this age level and branches into structure-of-intellect categories

which may not appear as unique abilities until later ages.

The implication from this study is that, should one wish to emphasize divergent production in elementary education, some tests for measuring such abilities do exist and can be developed further for the evaluation of such an emphasis. Further test development along these lines is in progress, including figural and symbolic abilities as well as those in the semantic area.

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TABLE I

ROTATED FACTOR MATRIX FOR SAMPLE OF COMBINED SCHOOLS AND GRADES (893 cases)

VARIABLE		FACTORS					
		A Maturation Effect	B Divergent Production of Semantic Units (DMU)	C Divergent Production of Semantic Transformations (DMT)	D Verbal I.Q. and Socio-Economic Status	E Divergent Production of Semantic Relations (DMR)	F Artifact
1. Treatment		−0.04089	0.01888	0.04601	−0.19711	−0.11123	0.00690
2. School District		−0.02102	0.03545	**0.17411**	**−0.70878**	−0.09255	−0.01132
3. Grade		**0.62096**	0.10191	0.28228	0.01048	0.13116	0.05187
4. Sex		**−0.29789**	**−0.27419**	0.21490	−0.07482	−0.08940	**0.27260**
5. Verbal I. Q.		0.24274	0.06626	0.15562	**0.64800**	0.12497	0.03707
6. Writing Speed		**0.51374**	0.10758	0.07549	0.16941	0.23797	−0.16163
7. Ways To Do It	Part 1	**0.48472**	0.12332	0.15364	0.25725	0.05588	0.06401
8. Ways To Do It	Part 2	**0.29197**	0.13119	**0.27281**	**0.51856**	0.08600	−0.04336
9. Ways To Do It	Part 3	**0.36629**	0.03365	0.05456	0.20988	0.11985	−0.02584
10. Similar Meanings	Part 1	0.22919	0.17882	0.22107	0.15952	**0.57255**	0.03574
11. Similar Meanings	Part 2	0.14364	0.24547	0.18766	0.11197	**0.62216**	0.02099
12. Similar Meanings	Part 3	0.18643	0.19723	0.18285	**0.28721**	**0.56279**	0.05853
13. What Would Happen (obvious)	Part 1	0.04642	0.24582	0.07496	0.19249	0.23882	−0.22330
14. What Would Happen (obvious)	Part 2	0.17813	**0.26466**	**0.28163**	**0.35652**	0.15313	−0.12824
15. What Would Happen (obvious)	Part 3	0.21342	0.23018	0.23026	**0.30198**	0.11426	**−0.46583**
16. What Would Happen (remote)	Part 1	**0.37655**	0.15793	**0.41590**	**0.44903**	0.06795	0.19708
17. What Would Happen (remote)	Part 2	**0.40247**	0.17519	**0.28862**	**0.34333**	0.08160	0.22573
18. What Would Happen (remote)	Part 3	0.12754	0.08921	0.17031	0.19938	0.17240	**0.51211**
19. Seeing Problems	Part 1	0.22538	**0.37631**	**0.35787**	**0.45117**	0.15770	−0.01384
20. Seeing Problems	Part 2	**0.29910**	0.32524	**0.32750**	**0.49154**	0.16535	−0.01372
21. Seeing Problems	Part 3	**0.30265**	**0.34650**	0.23592	**0.49260**	0.11028	−0.03182
22. Names For Stories (low)	Part 1	0.09472	**0.74254**	0.05288	0.03584	0.09224	−0.07133
23. Names For Stories (low)	Part 2	0.14063	**0.80387**	0.08540	0.11009	0.15236	0.02331
24. Names For Stories (low)	Part 3	0.07654	**0.77769**	−0.12474	0.01386	0.19788	0.03225
25. Names For Stories (high)	Part 1	0.20866	0.13331	**0.59533**	**0.28606**	0.22909	0.12957
26. Names For Stories (high)	Part 2	0.07922	−0.08462	**0.70124**	0.19047	0.20103	−0.00290
27. Names For Stories (high)	Part 3	0.21790	−0.01794	**0.71552**	0.10645	0.10976	0.00048

NOTE: A factor loading of .261 is significant at the .05 level.